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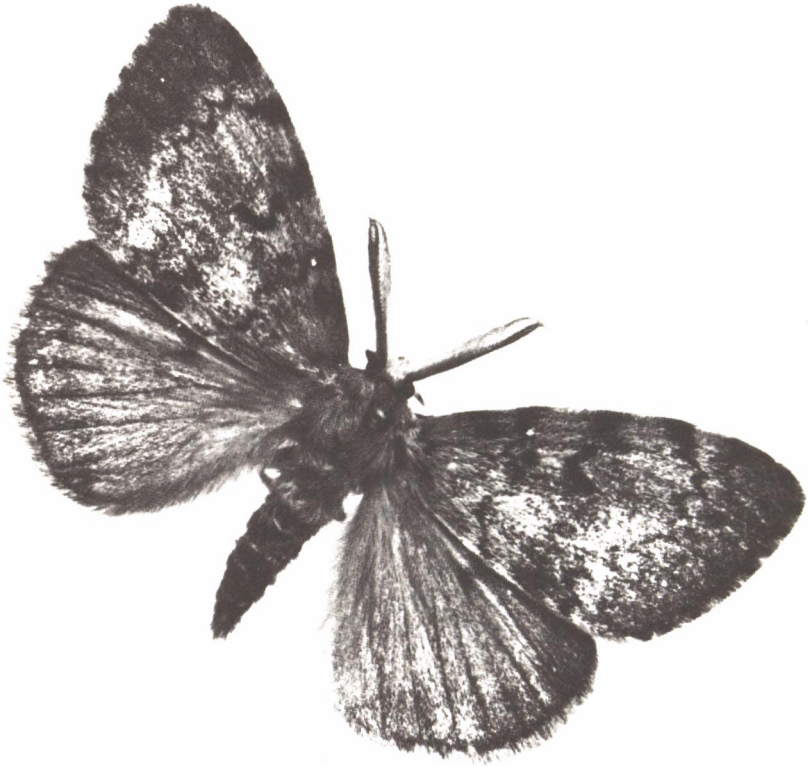

Pesticide Use in Forest Management

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If you have ever been ravaged by a horde of hungry mosquitoes — or shuddered at the sight of a fat, brown roach taking a shortcut across your buttered bread — or itched and blistered for weeks because of poison ivy — you know what a pest is.

None of those pestiferous organisms, however, had malice aforethought. Each was going its own way, solving its own problems in the only ways nature gave it.

As science uncovers more of nature's secrets, the more we realize the extent to which all life on this planet is interrelated. Each tiny insect, each towering tree, each molecule of soil in some way involves the other and all surrounding life.

Thinking man *(Homo sapiens)* has learned to look closely at other life forms and has begun to understand that human beings are just one of the myriad creatures who work best when all work together.

A pest, in the final analysis, is an organism that interferes with that working relationship. Among the thousands of insects in a forest, most are beneficial most of the time. Even those culprits with bad reputations such as the gypsy moth, the southern pine beetle, and the spruce budworm perform useful functions within their own ecosystems. And their populations are usually kept at harmless levels by natural means.

But our unique characteristics among living creatures have changed balances in nature. Human beings consciously direct their societies and establish their needs.

There was a time when the natural forests on this continent amply supplied our pioneer forebears. Virgin forests provided habitat for game; lumber for homes, furniture, bridges, and fences; and an abundance of wild fruit and nuts. And when the trees were harvested, there was good land for farming.

Adult male gypsy moth — The gypsy moth was introduced into the United States from Europe in the 19th century. Without natural enemies, it spread down the east coast and even across the country to the west coast. It is a defoliator; the larvae strip trees of their leaves.

But our burgeoning populations and westward migration overtook the ability of natural woodlands to provide society's needs. We began managing our forests, first to be sure they were not destroyed, then to provide wood for specific needs. We grew softwoods for paper pulp, hardwoods for veneers, pines for turpentine, and just the right trees to give us the telephone poles, ax handles, trailer bodies, violin soundboards, and ship decks that people require.

While we were taking these steps to provide the raw material for countless wood products, we were also providing banquets for some insects, cultures for some tree diseases, and rich soil for competing plant life. The key word is "competing." These insects, diseases, and weeds were recognized by land managers as organisms in competition with society for a natural resource. That is what a pest is. The insect, disease, or plant may have its beneficial role in a natural forest, but when it competes with human society, it becomes a pest.

Farmers have recognized what pests are, and have been combating them far longer than foresters. In fact, the methods for forest pest control had their roots in agricultural practices.

The search for ways to protect human food supplies from pests began far back in prehistory. Sulphur compounds were apparently being used to control insects and mites by the Sumerians in the Tigris-Euphrates valley 4,500 years ago. Around 300 B.C. the Chinese were adjusting planting times to avoid pests and using beneficial insects to devour pest insects.

Down through the centuries people have tried a wide range of control methods, some direct, some indirect. Directly, they weeded, gathered insects by hand, and used fire, chemicals, and biological agents. Indirectly, they manipulated the environment to hinder reproduction or survival — for example, by destroying favored breeding or resting places. They changed farming practices to minimize contact with pests and introduced or favored predators or parasites.

In post-Civil War America, farmers faced a growing problem with insects and expanded their search for methods of control. Paris green and other arsenicals were in use by the 1860's. Biological control dates from 1889 when the Australian ladybird beetle, or vedalia, was set loose on the cottony-cushion scale in California citrus orchards. But by the 1920's chemicals were dominant among pest control methods, primarily because they often gave visible, rapid, and even spectacular results.

The 1940s saw the development of several synthetic organic chemicals that were strikingly effective against insects and plants. These new compounds, of which the insecticide DDT and the herbicide 2,4-D were the most conspicuous, were effective against many pest species, were considered relatively nontoxic to other forms of life, and were suitable for aerial application. Very important to cost-conscious land managers, they were cheap enough to use in many areas where expense had previously barred direct control.

Aerial application — Applying pesticide from the air is an efficient, cost-effective method of pest management. On inaccessible terrain, it is often the only way to reach trees under attack from insect pests.

Forest pest management specialists followed a different path from their colleagues in agriculture. For ecological and economic reasons they relied less on chemicals. Forests are relatively stable ecosystems with a variety of natural mechanisms that control pest populations. Further, there were no widespread devastations from forest pests recorded in the 19th century. In the early days of our Nation, timber was too low in value, too generally available, and its growth cycle too long for the treatment of large forest areas to be economically feasible.

But as society's needs for wood products grew beyond the ability of natural forests to provide them, forestry specialists had to find ways to increase the usefulness of woodlands. Just as farmers had learned to keep weeds from choking and bugs from eating their crops, foresters had to learn to control the weeds and bugs that stunted or preyed on trees. With populations increasing and moving west, and with forest acreage dwindling, forest land managers began to borrow from agriculture's stock of available pesticides.

However, by the late 1940s, biologists were warning that DDT upset natural systems of pest control. And medical scientists were calling attention by the early 1950s to accumulating pesticide residues in human body fat. By the late 1950s public concern about pesticides was growing.

Because of scientific uncertainty about the safety of some chemical pesticides, research in recent years has increasingly focused on biological control methods. The deliberate introduction of exotic parasites is one such method. Others are the augmentation of native natural en-

emies of pests and the development of viruses and bacteria that reduce pest populations. These control methods have some critical advantages. In general, they are biologically specific to each pest requiring control and therefore pose little threat to other organisms, including human beings. But there is still much work to be done in this area. Effective formulations of biologicals have proved difficult to develop. Natural enemies introduced from foreign countries are hard to establish. And the present cost of biologicals often exceeds that of chemical pesticides.

The USDA Forest Service currently practices integrated pest management (IPM), a concept that may hold some of the answers to effective and acceptable pest control. In IPM the approach to controlling outbreaks is far different from the shotgun tactics used in the 1950s. With this system, the entire spectrum of pest management tools is available: mechanical, manual, chemical, and biological. A site specific analysis determines the safest, most efficacious, and most cost effective technique or combination of techniques to be used.

Biological control — This adult syrphid fly *(Syrphus opinator)* is the natural enemy of balsam wooly aphids. Such predators, along with parasites and pathogens, are used to reduce pest populations.

Timber losses caused by insects and diseases exceed even those that have grabbed newspaper headlines:

- The eruption of Mount St. Helens on May 18, 1980, left a spectacular swath of downed trees, 34.5 million cubic feet of timber laid flat. However, insects and disease kill 70 times that much timber **every year.**

- Forest wildfires kill an average of 100 million cubic feet of commercial timber annually. In that same period of time, insects and disease kill an average of 2.4 **billion** cubic feet. That's enough wood to build over 847,000 single-family homes.

- A single species of insect, the mountain pine beetle, has infested more than 1.5 million acres in the Western United States, and in one 5-year period killed more than 79 million trees.

- A single plant species, dwarf mistletoe, a parasite on western conifers, causes an annual loss of 393,460,000 cubic feet of timber.

The losses to standing forests are immediate, but the eventual damage is even more extensive. Watersheds are disrupted and the land suffers increased erosion. Wildlife cover is lost, particularly for elk, deer, and grizzly bear. Campgrounds are abandoned or moved because pests kill the trees that make them attractive recreation areas. Property values plummet as the trees die. Furthermore, dead trees add available fuel and thereby increase the risk of wildfires.

Perhaps more important potentially than the damage to forests in general is the danger pests pose to seed orchards and nurseries. Here the seeds for future woodlands originate, and here genetically superior trees get their start.

Woodlands are not the only concern of the Forest Service; the agency also pro-

Severe erosion — Loss of trees and other vegetation opens the land to wind and rain. On highly erosive soil such as the southern coastal plains of Mississippi, the land washes away, leaving desolation.

tects more than 4 million acres of grasslands. Pests on this acreage range from the exotic to the ordinary. An exotic such as knapweed, introduced from Europe, has already overrun more than 2 million acres of our inland Northwest. It is more than a pest; it is an insidious killer. Its roots secrete a chloroform-like chemical that kills vegetation around it, leaving the soil infertile — except for more knapweed. Horses that eat it become glassy-eyed and paralyzed; some eventually die.

Among the more common pests of rangelands are grasshoppers. They can eat more grass than cattle. An epidemic of these insects can reduce the forage of grazing cattle by 50 percent in just a few weeks.

It is indeed fortunate that most insects and other forest and range organisms are beneficial. Yet of over a million species of insects, some 10,000 are classified as pests in the United States. There are about 45,000 species of fungi, 1,500 parasitic plants, 12,000 species of nematodes of which 1,500 are parasites, and 2,000 weed species of which 600 are known to cause economic loss.

Without pesticides, we would suffer overwhelming resource destruction and grave economic injury.

Pest management as practiced by the Forest Service today is concerned first with prevention, managing resources to forestall conditions that favor pest outbreaks.

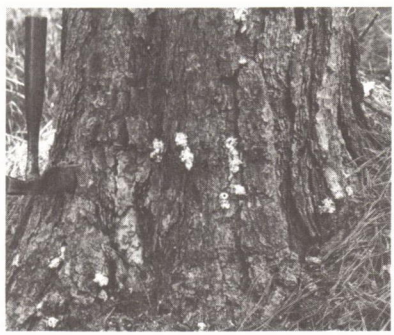
It is known that when each tree in a stand has the proper sunlight, soil nutrients, and water, it is better able to ward off attack by diseases and insect pests. Steps to ensure access to these vital elements begin before seedlings are planted. Competing vegetation is removed and kept in check until planted or seeded-in trees are large enough to grow on their own.

Trees within a stand compete among themselves too; so regular thinning is required to relieve biological stress. This requires access roads for crews and equipment.

Research is continuing to develop trees that resist attack, and to produce superior trees that grow larger and faster on a given amount of sunlight, water, and nutrients.

Even when prevention is practiced, pest outbreaks still occur, for reasons not thoroughly understood as yet. When this happens, suppression methods must be employed.

Pest outbreaks, or epidemics, and their likelihood may be determined in a number of ways. Most insects that cause major damage in large numbers are always in the forest, but at population levels that do not threaten trees. Such populations are called endemic, that is, they are commonly found in the area. When endemic populations begin to increase rapidly or move rapidly into a new area, they are called epidemics or outbreaks. Sometimes these are discovered when increasing numbers of specimens are caught in traps, sometimes when indications of the pest's behavior become visible, such as pitch tubes or fallen sawdust where the insect has bored through bark. Other signs are



Pitch tubes — These popcorn-like discharges from a ponderosa pine indicate the presence of bark beetles, marking spots where beetles have bored through the bark.

defoliation and characteristic color changes in foliage. Examination of habitat by entomologists can often foretell population changes and the likely extent and magnitude of damage.

When an outbreak is imminent, an economic analysis is conducted. This will be one of the factors entering into the decision to treat or not to treat an area. It may be that the epidemic is considered of "natural" proportions, serving the function of weeding out weakened, unproductive trees, and no action will be taken. Sometimes the cost of treatment will far exceed the value of the trees that would be saved, and no action will be taken. Or perhaps the extent of anticipated damage is not large enough to warrant treatment.

On the other hand, the endangered trees may be highly valuable. They may constitute important habitat for wildlife; they may be critical in stabilizing erosive soil and preventing degradation of water quality; their esthetic appeal may influence tourist or resident appreciation of the area and their loss could endanger local economies and land values; there may be adjacent, more valuable, stands

Wildlife — The maintenance of wildlife habitat is a major reason for controlling pests. Pest management is designed to protect all natural resources of our woodlands and grasslands.

of trees into which the insects may move; or the stand in question may be an important natural resource.

Once the decision to treat has been reached, there are other considerations to be studied. What of the land on which the stand is growing? Is it too irregular for ground access? Do roads or trails exist? Is the soil highly erodible or subject to compaction from heavy equipment? Is it so inaccessible or steep that only aerial treatment is possible?

And what of the insect pest itself? Are there biological agents it will succumb to: parasites, predators, or pathogens? Are its numbers so great and the infestation so severe that biological treatment will be too costly or too slow to save the trees?

If, as a last resort, only a chemical pesticide remains as an effective and timely suppressant, other kinds of analyses are pursued. For instance, can the infestation be treated by subareas? Perhaps some of the land can be treated by ground application. Research shows, however, that this is more hazardous to applicators than aerial application. Other areas, not so imminently threatened, may be suitable for biological treatment. Then only the most severely attacked and least accessible land would receive aerial application of a chemical pesticide.

Still there are more analyses. Of the pesticides registered by the Environmental Protection Agency for use against the pest in question, which is safest under the given circumstances? The most effective? The least costly?

The number of decisions required to protect our forests from destructive pests seems endless. Only a few have been touched on here. For instance, a land manager may decide to treat an area manually for weed control to reduce the impact on water quality and nearby human activity. Yet that decision must be weighed against the probability of more injuries to the crew using hand-tools instead of pesticides to clear vegetation. The risks to the crew using heavy equipment in a mechanical operation are even higher. All these issues must be taken into account.

How does a land manager weigh the probabilities of injury? By what means can account be taken of all the variables before reaching decisions, particularly those involving scientific data? Scientists themselves do not have all the answers. Even among specialists there is uncertainty concerning the properties of certain chemical compounds and their effects on humans, wildlife, and the environment. Consequently, there is no body of accepted and irrefutable facts upon which to base judgments.

Forest Service decisionmakers have a primary responsibility to carry out their duties safely. The well-being of the public and the people who work for them are paramount concerns. And land managers are well aware that when pesticides are needed, they will be working with material that is toxic in varying degrees. Managers know there are concerns about the potential for cancer (carcinogenicity), changes in inherited characteristics (mutagenicity), and deformed offspring (teratogenicity).

A tool decisionmakers use in weighing these dangers is called risk analysis. By mathematical means, the risk involved in using a particular pesticide can be calculated. Further, that risk can be compared to other risks that are generally considered acceptable or unacceptable.

For instance, there is a certain risk in walking across a street; there is a greater risk in crossing against a traffic light; and there is a still higher risk in crossing against a light blindfolded. The level of these risks can be expressed mathematically.

The decision point comes in balancing the risk against a goal that is desired. Most people will cross a street to get to a store. Many will cross against the light to catch a bus that is about to leave. And a mother might try it blindfolded to save her child from dire injury.

Risk analysis in forest management is a statistical method for determining the kind of risk posed by the use of a particular substance and the probability of various groups being exposed to that risk. With these data, the resource manager is better able to make a reasoned judgment in balancing the risk against management goals.

The calculations take into consideration the potential for certain people — such as pesticide applicators, loaders, and handlers; hunters and hikers; and residents at varying distances from the area being studied for treatment — to be exposed to pesticides. Analyses include the possibilities for exposure through the skin, via the mouth, and by breathing. The likelihood of multiple exposures is investigated, as are the chances for accidents and misapplications. When all these data are presented to the land manager, that decisionmaker is then in a position to decide for or against pesticide use and what safeguards are necessary if a pesticide is decided upon.

When a woodland manager is faced with losing a valuable public resource and the only recourse is to use a pesticide, a risk analysis is used. There are times when the magnitude of risk of injury to people, wildlife, or the environment is such that the pesticide will be eliminated from consideration.

After weighing the odds, each resource manager will make a decision based on his or her best judgment. As we all do — every day.

This publication reports research involving pesticides. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

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